Emerging Sports Concussion Science and DoD Collaborations with Professional Athletics

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National Director

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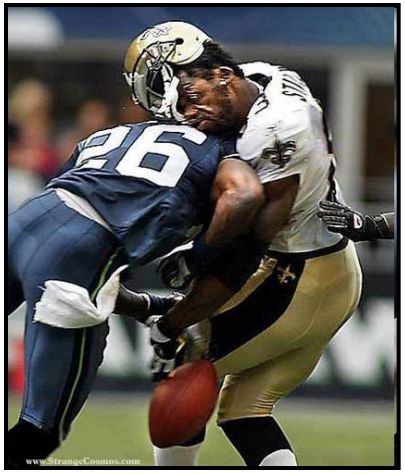
Emerging Sports Concussion Science

- Epidemiology
- Biomechanics
- Neuroimaging
- Neuropathology



Need to Understand Risk of Recurrence

- Each year, U.S. emergency departments treat an estimated 135,000 sports- and recreation-related TBIs, including concussions, among children ages 5 to 18. *(MMWR* July 2007)

- National Center for Catastrophic Sports Injury Research
  - Study of scholastic sports injuries over 13 seasons (1989-2002)
  - Catastrophic injuries
    - 40% were playing with mild symptoms from prior injury
      - 71% were injuries from same season

- National High School Sports-Related Injury Surveillance Study
  - 68,000 Concussion during 2008 Season
    - 16% of Players with LOC returned to field the same day

Natural History

- Football
- High School
  - Powell et al, JAMA, 1999
  - Guskiewicz et al, AJSM 2000
- College
  - Guskiewicz et al, JAMA 2003
  - Guskiewicz et al, AJSM 2000
- NFL
  - Pellman et al, Neurosurgery 2004
  - University of Michigan Institute for Social Research 2009
- DoD
- Vietnam Head Injury Study
  - Increased findings of cognitive dysfunction compared to age-matched controls
- Combat/Blast
  - Congressionally-mandated 15-year longitudinal study launching

NCAA Concussion

- Sports as a Laboratory Model (SLAM)
- University of Virginia
- Mid-80s
  - Barth et al
    - Medical Director of VA Neurocare DVBIC
- Baseline cognitive studies and post-injury evaluations revealed cognitive deficits in sports concussion with either LOC or AOC
- Research utilized in development of initial RTP guidelines

- History of 3 previous concussions increases the risk of repeat concussions 3-fold (Guskiewicz, 2003)
- Athletes with a history of 3+ concussions report significantly more symptoms, lower memory scores at baseline
- Symptoms following repeat concussion may be more serious and resolve at a slower rate

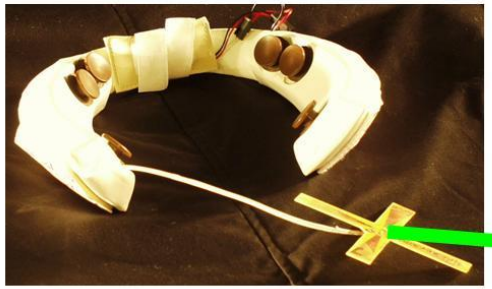
NFL Studies

CONCUSSIVE EFFECTS/TBI

• A study commissioned by the NFL reports that Alzheimer's disease or similar memory-related diseases appear to have been diagnosed in the league's former players vastly more often than in the national population – including a rate of 19 times the normal rate for men ages 30 through 49.

-Study conducted by University of Michigan's Institute for Social Research

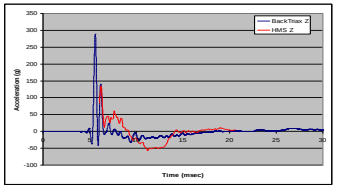
Helmet Detectors



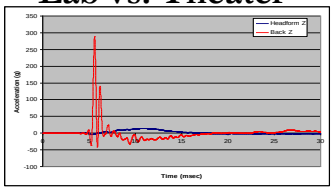
Wireless Helmet Accelerometer System

Internal Mount Sensor

External Mount Sensor



Lab vs. Theater



Sensor vs. Headform

Newer Helmet Monitoring Technologies

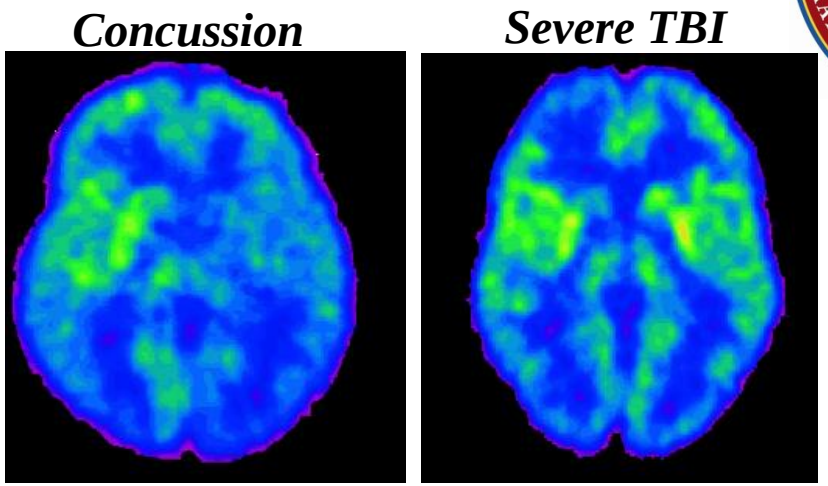
- Continues to grow at college level
  - •University of Minnesota added system for 2007 season
  - •Users Include: VA Tech, Oklahoma, UNC, ASU, Dartmouth, Indiana, Illinois x 2, Brown, Minnesota
  - •System added to 4 UPMC study high schools for 2006 playing season (5 concussions in HITS Equipped helmets)
  - •650,000+ impacts recorded to-date

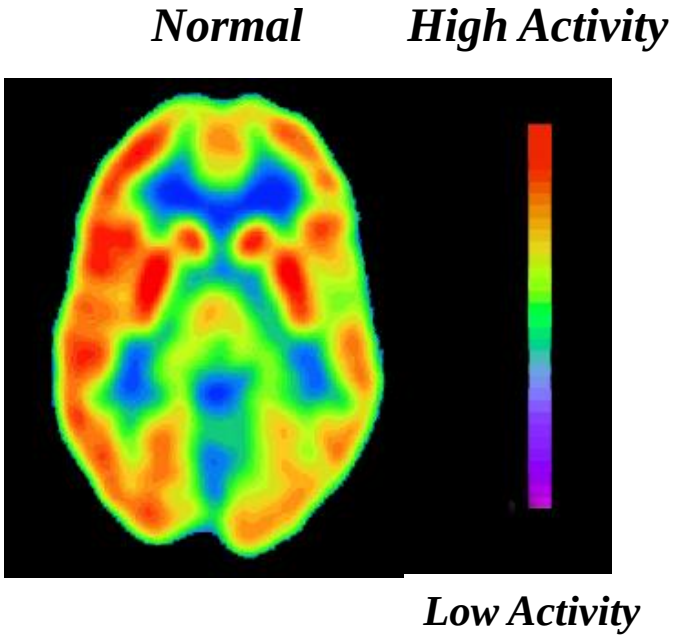
- What has been learned from monitoring and other biomechanics studies?
- Players still lead with their heads –generally higher magnitude impacts to top of head (UNC)
- Importance of rotation
- Incidence correlates with position
- Concussion case studies at Virginia Tech –peak head acceleration averaged 104 g's for 3 diagnosed concussions

Functional Imaging

- Assessment of neuronal/metabolic function

- Informing DoD policy -- undiagnosed concussion can result in:
  - Symptoms affecting operational readiness
  - Risk of recurrent concussion during the healing period





Bergsneider et al., J Neurotrauma 17:2000

Imaging: mTBI and Depression

An fMRI Study of Male Athletes

- Athletes with symptoms of depression with onset after concussion showed reduced activation in the dorsolateral prefrontal cortex and striatum, and attenuated deactivation in medial frontal and temporal regions.
- The severity of symptoms of depression correlated with neural responses in brain areas that are implicated in major depression.
- Voxel-based morphometry confirmed gray matter loss in these areas.
- Conclusion: Depressed mood following a concussion may reflect an underlying pathophysiology consistent with a limbic-frontal model of depression.

Neural substrates of symptoms of depression following concussion in male athletes with persisting postconcussion symptoms. Chen JK, et al. Arch Gen Psychiatry. 2008 Jan;65(1):81-9.

Chronic Traumatic Encephalopathy (CTE)

Center for the Study of Traumatic Encephalopathy (CSTE) at BU School of Medicine

- "A distinct disease with a distinct cause, namely repetitive head trauma" *(Ann McKee, MD, CSTE co-director and neuropathologist)*
- CTE diagnosed in 6 former NFL players since 2002, including:
  - Pittsburgh Steelers - Mike Webster, Terry Long and Justin Strzelczyk
  - Tampa Bay Buccaneer Tom McHale, died at age 45
- Youngest case to date: 18-year-old boy who suffered multiple concussions in high school football

Clinical Sequelae of Chronic Traumatic Encephalopathy

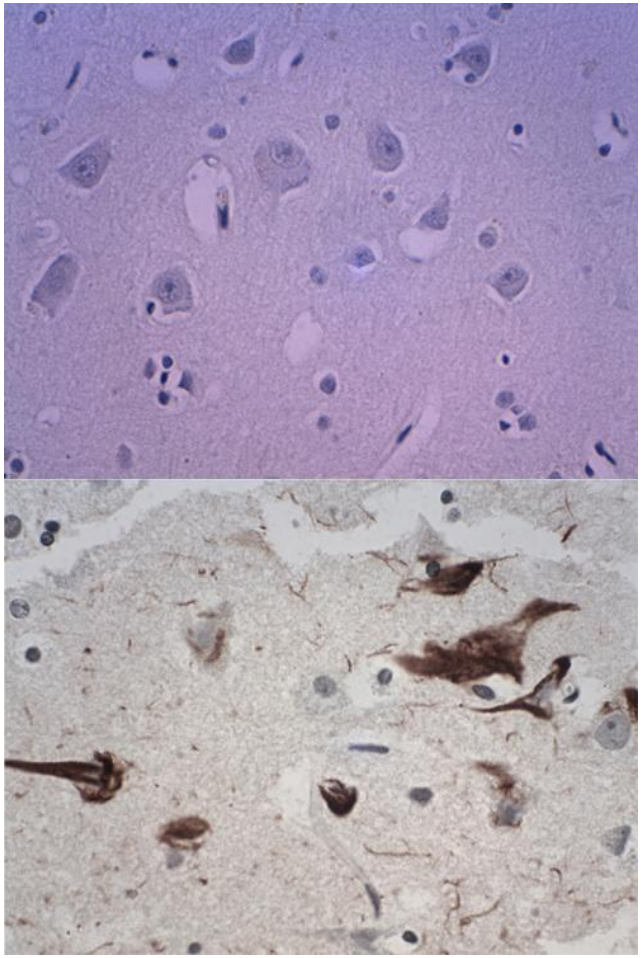
Symptoms can include:

- Memory disturbances
- Behavioral changes
- Personality changes
- Parkinsonism
- Speech abnormalities
- Gait abnormalities

Sports Legacy Project

Christopher Nowinski and the Sports Legacy Institute

Top: Slide detailing x600 magnification of immunostained neocortex in a non-CTE damaged brain.



Chris Benoit, Professional Wrestler

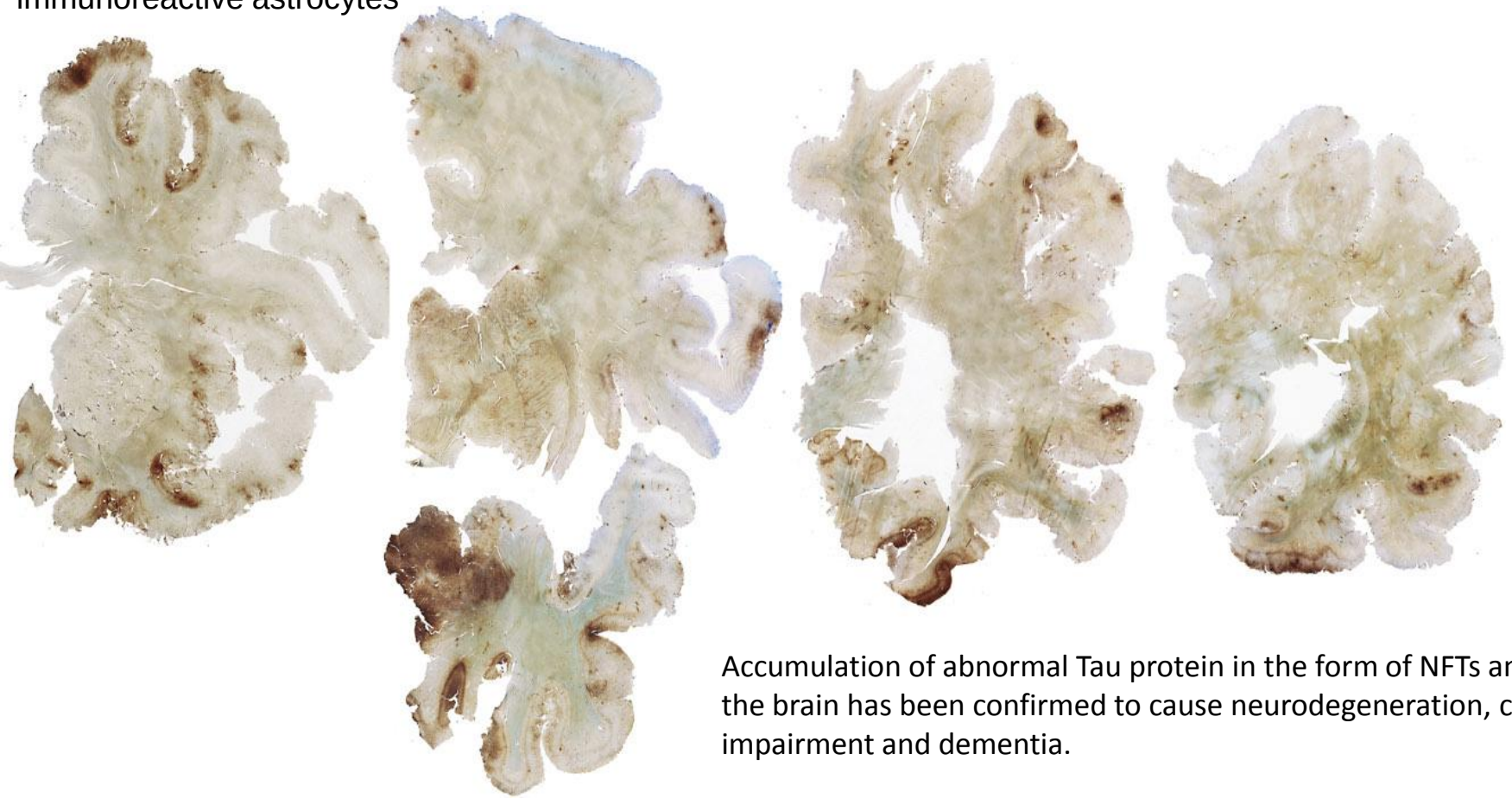
Bottom: Slide detailing x600 magnification of Chris Benoit's tau-immunostained neocortex showing neurofibrillary tangles, neuritic threads, and several ghost tangles indicating CTE.

Source:
http://www.sciencedaily.com/releases/2007/09/070905224343.htm

Image courtesy of Sports Legacy Institute

Progressive Tauopathy in an athlete with Chronic Traumatic Encephalopathy

Tau-immunoreactive neurofibrillary tangles in the superficial cortical layers of the frontal, subcallosal, insular, temporal, and parietal cortices and the medial temporal lobe; marked accumulation of tau-immunoreactive astrocytes



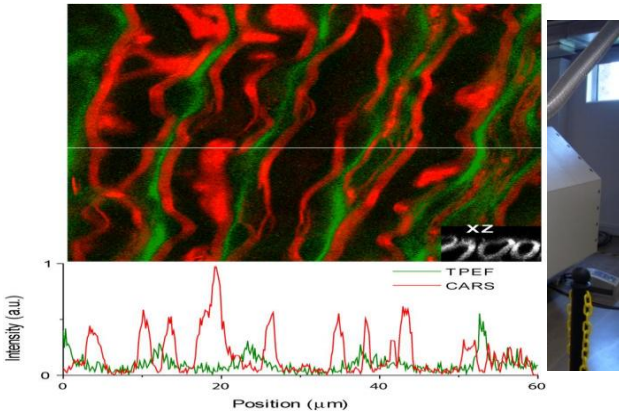
Accumulation of abnormal Tau protein in the form of NFTs and NTs in the brain has been confirmed to cause neurodegeneration, cognitive impairment and dementia.

Coronal sections immunostained for tau with monoclonal antibody AT8 and counterstained with cresyl violet
McKee AC, Cantu RC, Nowinski CJ, et al, J Neuropathol Exp Neurol Volume 68, Number 7, July 2009

DoD Brain Bank

- Unclear how emerging neuropathology findings of recurrent sports concussions may apply to blast TBI
- Currently, there is limited neuropathology information on blast TBI
- DVBIC-AFIP TBI Research Center to partner with AFME to study neuropathological effects
  - Preliminary evidence suggests importance of white matter

Armed Forces Institute of Pathology



DoD Collaborations

- NFL
  - DVBIC facilitated information exchange between DoD and NFL
    - Context for similarities and differences
  - DoD ex officio representative on NFL Concussion Committee
  - Representatives on NFL Players Association Concussion Committee
    - DVBIC and NICoE
- PGA
  - Wounded Warrior Golf Clinics
    - Ft Carson Wounded Warriors and DVBIC
- MLB
  - Welcome Back Veterans
    - Red Sox and Boston VA DVBIC and Polytrauma Programs
- NASCAR
  - Accelerometer discussion with Army and DCoE

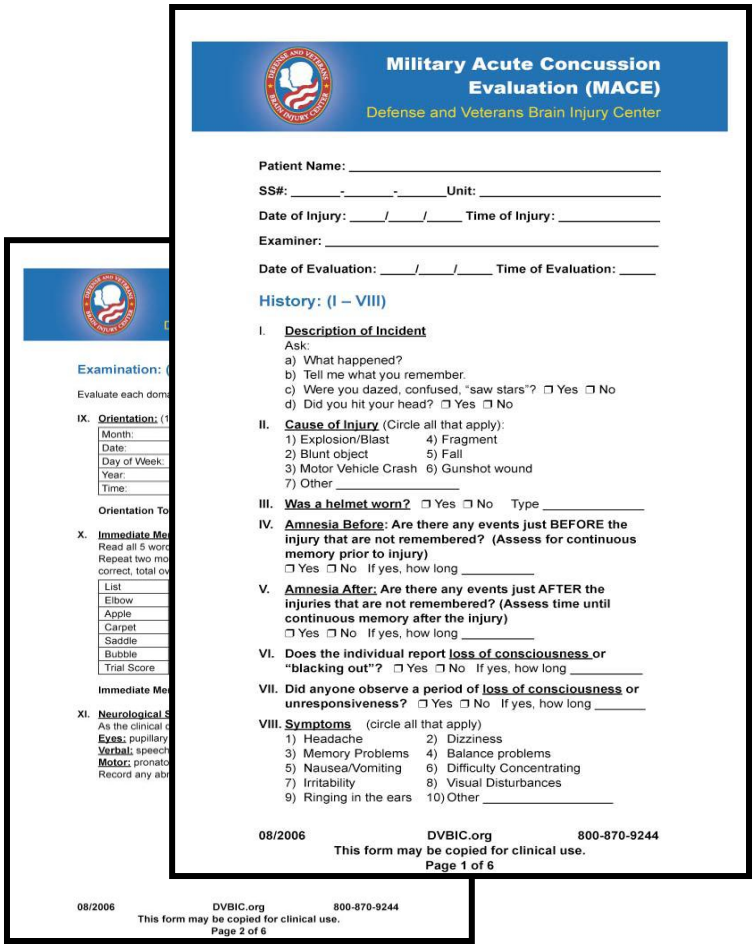
Collaboration Results

- Research and information exchange informed latest revisions in concussion guidelines for both NFL and DoD
  - Sports Standardized Assessment of Concussion (SAC) incorporated into MACE
- Informed DoD Materiel Community in RFP to optimize helmet lining and protection
- Informed NCAT baseline initiatives
- Cultural Change
  - Reflected in senior leader approach and PSAs

Military Acute Concussion Evaluation (MACE)

- MACE was developed by the DVBIC and released in Aug 2006
- Screening tool in deployed CPG
- Adapted by several NATO allies

- 3-Part Screening Tool – "CNS"
  - Cognition –
    - Adaptation of SAC
  - Neurological Screening Exam
  - Symptoms and History



Military Acute Concussion Evaluation (MACE)
Defense and Veterans Brain Injury Center

Patient Name: _____

SS#: _____-_____-_____Unit: _____

Date of Injury: ____/____/____ Time of Injury: _____

Examiner: _____

Date of Evaluation: ____/____/____ Time of Evaluation: ____

History: (I – VIII)

I. **Description of Incident**
Ask:
a) What happened?
b) Tell me what you remember.
c) Were you dazed, confused, "saw stars"? ❒ Yes ❒ No
d) Did you hit your head? ❒ Yes ❒ No

II. **Cause of Injury** (Circle all that apply):
1) Explosion/Blast 4) Fragment
2) Blunt object 5) Fall
3) Motor Vehicle Crash 6) Gunshot wound
7) Other _____

III. **Was a helmet worn?** ❒ Yes ❒ No Type _____

IV. **Amnesia Before: Are there any events just BEFORE the injury that are not remembered? (Assess for continuous memory prior to injury)**
❒ Yes ❒ No If yes, how long _____

V. **Amnesia After: Are there any events just AFTER the injuries that are not remembered? (Assess time until continuous memory after the injury)**
❒ Yes ❒ No If yes, how long _____

VI. **Does the individual report loss of consciousness or "blacking out"?** ❒ Yes ❒ No If yes, how long _____

VII. **Did anyone observe a period of loss of consciousness or unresponsiveness?** ❒ Yes ❒ No If yes, how long _____

VIII. **Symptoms** (circle all that apply)
1) Headache 2) Dizziness
3) Memory Problems 4) Balance problems
5) Nausea/Vomiting 6) Difficulty Concentrating
7) Irritability 8) Visual Disturbances
9) Ringing in the ears 10) Other _____

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This form may be copied for clinical use.
Page 1 of 6

Examination:

Evaluate each dom

IX. Orientation:

Month:
Date:
Day of Week:
Year:
Time:

Orientation To

X. Immediate Me
Read all 5 word
Repeat two mo
correct, total ov

List
Elbow
Apple
Carpet
Saddle
Bubble
Trial Score

Immediate Me

XI. Neurological S
As the clinical
Eyes: pupillary
Verbal: speech
Motor: pronato
Record any abn

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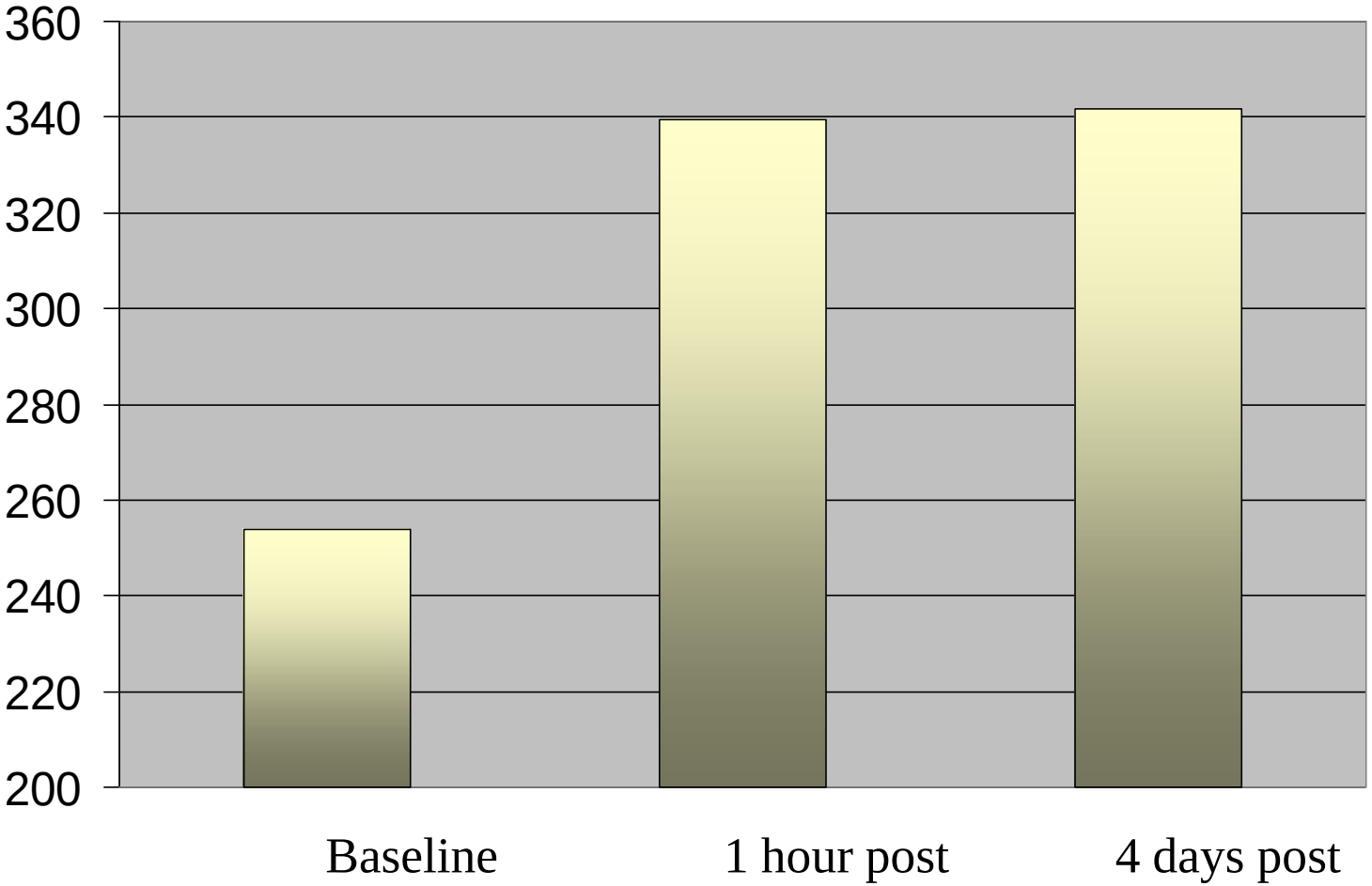
Page 2 of 6

USMA Concussion Study
Simple Reaction Time

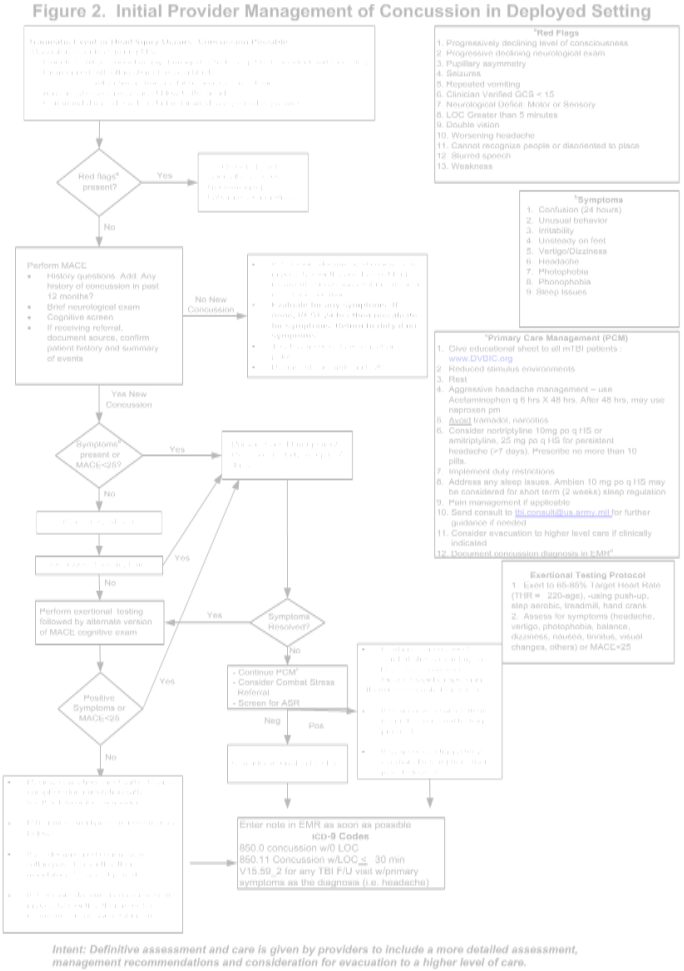
$p < 0.05$



Warden D, Bleiberg J, Cameron K, et al, Neurology, 2001

Theater Concussion Clinical Practice Guidelines

- Updated to incorporate recurrent concussion guidance and mandatory rest
- Review Red Flags
- Perform MACE
- Primary Care Management
  - Medications
  - Headache management
  - Address sleep
- Refer to Role III for:
  - Specialty services, neuroimaging,
  - laboratory capability
- Algorithms for
  - Medics / Corpsmen
  - Initial Provider
  - Comprehensive



Statement on Return-To-Play

The NFL's Mild Traumatic Brain Injury Committee

The player who suffers a concussion should not return to play or practice on the same day if there is:

1. Loss of consciousness, as determined by the team medical staff.
2. Confusion, as evidenced by disorientation to person, time or place; inability to respond appropriately to questions; or inability to remember assignments or plays. If a player experiences acute confusion, it may not be possible to conduct other aspects of the exam at that time.
3. Amnesia, as evidenced by a gap in memory for events occurring just *prior to* the injury (as determined by questioning by the medical staff); inability to learn and retain new information (such as three words); or a gap in memory for events that occurred *after the injury (again, based on questioning by the* medical staff).
4. Abnormal neurological examination (i.e., abnormal pupillary response; persistent dizziness or vertigo; abnormal balance on sideline testing (e.g., Romberg test)).
5. New and persistent headache, particularly if accompanied by photosensitivity, nausea, vomiting, or dizziness.
6. Any other persistent signs or symptoms of concussion.

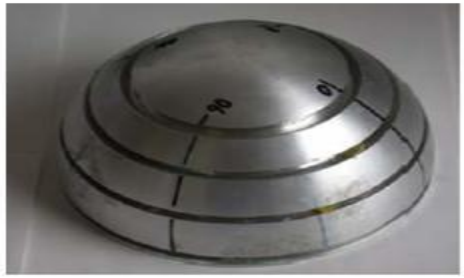
Statement on Return-To-Play

The NFL's Mild Traumatic Brain Injury Committee

- Once removed for the duration of a practice or game, the player should not be considered for return-to-football activities until he:
  - is fully asymptomatic, both at rest and after exertion
  - has a normal neurological examination
  - has normal neuropsychological testing
  - has been cleared to return by ***both*** the team physician(s) and the independent neurological consultant
- A critical element of managing concussions is candid reporting by players of their symptoms following an injury. Accordingly, players are to be encouraged to be candid with team medical staffs and fully disclose any signs or symptoms that may be associated with a concussion.

Helmet Design Evolution and Evaluation

Validation Tests

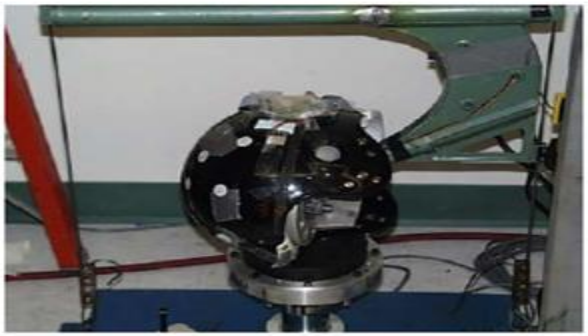


Hemisphere Drop Impacts

Helmet to Helmet Impacts

Pneumatic Impactor Tests (Wayne State)

Impactor to Helmet Pendulum Impacts (Biokinetics)



Helmet Drop Impacts

Baselining to Enhance Post-Injury RTD/RTP Determination

NCAT

- Over 455K baselined in DoD as of 31 Dec 09
- Army ANAM Ops
- ImPACT – experience in sports
- DETECT

Cultural Change

- Emerging science supports acute management to include concerns of safety to encourage acute management and evaluation to prevent recurrent concussions before full recovery from prior injury
- State Laws:
  - Washington – first state legislation
  - Oregon
  - Texas
  - Under consideration: ME, CA, MA, NJ, NY

Public Service Announcements

- NFL: Take Head Injuries Out of Play
  http://www.nfl.com/videos/nfl-network-around-theleague/09000d5d814d2543/Concussion-safety

- DoD: Protect your strongest weapon – your brain!
  http://www.facebook.com/video/video.php?v=104824466213664